Development and Fabrication of Automatic Pump-down System for Split Unit Air Conditioning System

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ABSTRACT – Pump-down is a process of storing refrigerant in the outdoor unit. In normal practice, pump down was done manually before any service or repair. This experimental project focused on developing an automatic pump-down system attached to split-unit as part of leak prevention effort. A 1 hp split-unit was connected with two set of pressure switches and solenoid valves work as stopper to shut of both lines in the event of leakage. Compressor continue running until all refrigerant were pumped into the outdoor unit. Few leakage case were constructed to examine the capability of the new automatic pump down system. The results show that 99.98% refrigerant were able to recovered.

1. INTRODUCTION

Refrigerant leakage on split type household air conditioner (STHAC) may cause bad impact on environment as well as the system itself [1,2]. The leak of refrigerants may also increase financial cost to repair the air-conditioning system. Refrigerant leakage normally occurs in the event of joint failure or leaking seal [3]. The emission of the refrigerant such as CFC and HCFC used in STHAC due to leakage, may cause depletion of ozone layer.

Automatic pump-down (APD) system may become a practical solution to both issues by keeping the remaining refrigerant in the system while waiting for personnel to come and repair the leak. Similar approach system to solve the problem were found available for chiller system. Automatic pump down is currently only available on City Multi R2 heat recovery VRF provided by Mitsubishi Electric. However, the system is only for big chiller system but not for small air-conditioning less than 3 hp [4].

2. METHODOLOGY

The selected STHAC for this study was 1 hp Acson brand split unit. It has maximum current input of 4.21 Ampere at 600 g HCFC 22 refrigerant. The current reading at this pressure was at 3.8 Ampere. The outdoor unit was modified in order to install additional solenoid valves and pressure switches. Refrigerant drives by compressor flow through condenser and capillary tube before entering indoor unit. A pressure switch and a solenoid valve 1 (SW1) were installed on the high pressure line between capillary tube and connector that joints outdoor unit to the indoor pipe. Another set, solenoid valve 2 (SW2) were installed on the low pressure line before refrigerant entering the compressor again. Location of switches and valves installed were illustrated in Figure 1.

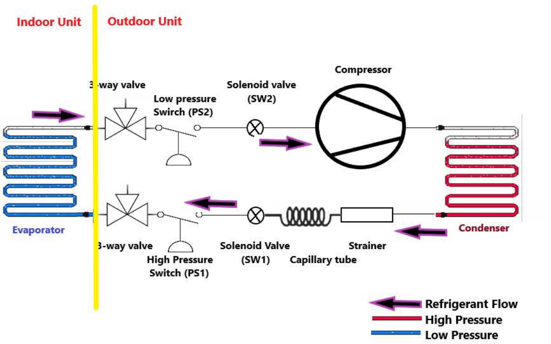

Figure 1: Installation of additional switch and valves

The pressure switch SW1 was set slightly below the recommended pressure of the refrigerant on high side; in this case 109 psi while SW2 was set at 0 psi. Whenever leaks occur on the circulated line, low pressure condition were sense by the APD. Controlled by Arduino micro controller, APD shut off SW1 to cut the circulation. In the same time, compressor continues running to pull remaining refrigerant from indoor unit to outdoor unit. Low pressure line will have vacuum condition from the effect of running compressor. After the SW2 reach 0 psi, APD shut off everything and light up an red LED to indicate the whole process was done.

In this project, control system and wiring system are also being modified. The modification needed to replenish wiring pressure switches and solenoid valves. Sources of supply for electric fan, pressure switch, solenoid valves and compressor are all connected to get electricity supply from indoor unit. Neutral wire from fan, solenoid valves, compressor and pressure switches are also connected together. When pressure setting in the low pressure switch detected changes in refrigerant pressure, the solenoid valve will operate. At the same time, the indicator light (green) is on, which is indicating the running of APD. Solenoid valve in the discharge line will block the refrigerant from leaving the outdoor unit. During this process, the compressor still operates to pump the balance refrigerant to outdoor unit. When pressure at suction detects at 0 psi, pressure switch will operate and send signal to activate the solenoid valve, thus blocks the remaining refrigerant from entering indoor unit. Besides that, low pressure switch also can shut off the power supply for the outdoor unit. Red indicator LED lighted up to show that the pump down process was completed. Figure 2 shows the modification on wiring outdoor unit.

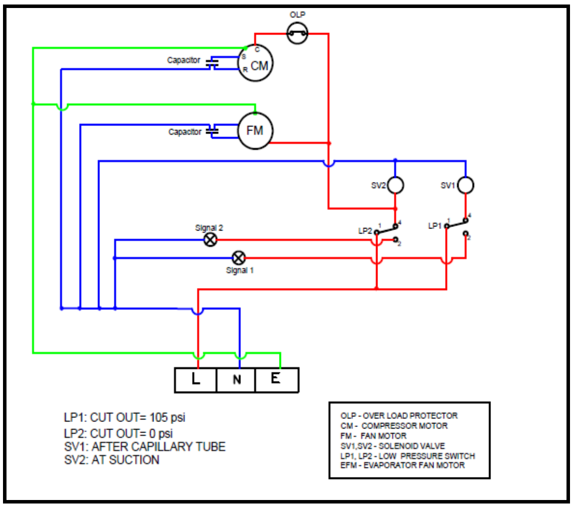

Figure 2: Diagram of wiring modification on experimental unit

3. RESULTS AND DISCUSSION

To determine setting pressure for SW1, few cases (110 – 80 psi) were conducted, since it gives impact to the system at two conditions, when sets too high, will make the APD works at unreasonable condition while sets too low will allow more refrigerant emit to atmosphere.

At 110 and 105 psi pressure setting, APD activated even no leak simulation was applied on the system. This situation happened because the pressure produce by the compressor is not stable during the circulation process due to many obstacle and different condition faced by the refrigerant when completing the circulation. Therefore, 110 and 105 psi are not suitable for pressure setting.

Next, SW1 was set to pressure setting 100 to 80 psi with interval of 10 psi desending. The amount of refrigerant recover was presented in Figure 3. Figure 3 also describes current supplied to the system and time taken for the APD to recover the refrigerant.

It is clear shown in Figure 3, that the best pressure setting for SW1 is at 100 psi. The amount of refrigerant recovered is 599.88 g which equivalent to 99.98% from the total 600 g charged previously. The value also bring the meaning APD only allow emission of 0.12 g HCFC 22 refrigerant to atmosphere at any occasion of leakage.

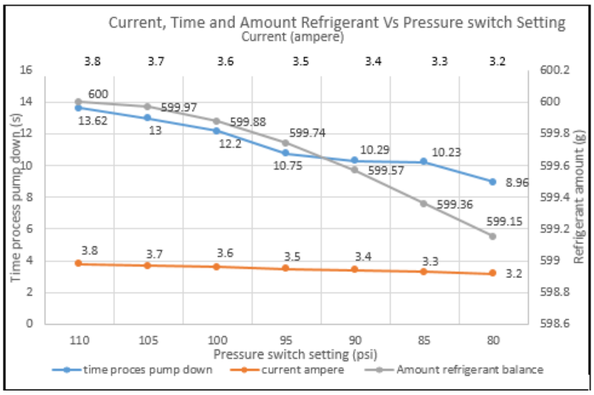

Figure 3: Recovered refrigerant amount, time taken and current supply for different pressure setting

4. CONCLUSIONS

The APD system was presented by installing to 1 hp wall mounted STHAC system. The system also well controlled by using Arduino micro controller to cater the leakage of refrigerant. It is found that APD system can recover 99.9% of refrigerant from exposing to the atmosphere at pressure setting 100 psi. In the future, APD would be used to all STHAC system to reduce refrigerant emissions.

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